Panasonic

LLC Resonant Converter with EVB-MV103HFXX-KIT

Kit Reference Guide Ver.1.0

Pub.No. GP010101-010E

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Chapter 1 Introduction

Chapter 2 Specifications

Chapter 3 Other information

Table of Contents

LLC Reference Kit USER AGREEMENT 5
Important notice 8

Chapter 1 Introduction 10

1.1 Overview and Features 11
1.2 Kit Contents 12
1.3 Optional accessory products 13

Chapter 2 Specifications 14

Chapter 3 Other information 17

3.1 Visual Appearance of Each Board 18
3.2 Pins and Connectors 21
3.2.1 Pin Information 21
3.2.2 Connector information 21
3.3 Reference 22

Support information 23

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The terms used in this Agreement are defined as follows.

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(2) In the event that this Agreement is terminated in accordance with the subsection 1 of this Article 10 above, Licensee shall promptly (i) stop the use of Deliverables; (ii) return to Licensor the Hardware; (iii) destroy the Software and all the copies thereof, if any and (iv) provide Licensor with a written statement certifying that it has complied with the foregoing obligations.
(3) In the event that this Agreement terminated in accordance with the subsection 1 of this Article 10 above, Licensor shall not reimburse any amount paid by the Licensee to the Licensor in relation to or in connection with this Agreement.

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(1) This letter shall be in effect for a period of one (1) year from the date of signature by Licensee unless terminated pursuant to this Agreement, and shall be automatically renewed and continue on a year to year basis unless the Licensor and Licensee agree to terminate this Agreement at least three(3) months before the expiration of the original or any subsequent term of this Agreement.
(2) Notwithstanding the subsection 1 of this Article 11, Licensor may terminate immediately this letter with written

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(3) In the event of the expiration of this Agreement, Upon the request of Licensor, Licensee shall (i) stop the use of Deliverables; (ii) upon the request of Licensor, return to Licensor the Hardware and/or destroy the Software and all the copies thereof, if any and provide Licensor with a written statement certifying that it has complied with the foregoing obligations.

Article 12 Survival Clause

In the event that this Agreement is terminated and Licensor requires Licensee, Licensee shall promptly (i) stop the use of Deliverables; (ii) return to Licensor the Hardware; (iii) destroy the Software and all the copies thereof, if any and (iv) provide Licensor with a written statement certifying that it has complied with the foregoing obligations. Notwithstanding the foregoing, Article 8 and this Article shall survive for three (3) years after any expiration or termination of this Agreement.

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This Agreement shall be governed by, and construed in accordance with, the laws of Japan, without regard to conflicts of law rules. All disputes, controversies, claims or differences which may arise between the Licensor and Licensee, out of or in relation to or in connection with this Agreement, or for the breach thereof, shall be determined exclusively by courts having jurisdiction over the place where the business office of the Licensor is situated.

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The Licensee and the Licensor agree to cooperate and discuss in good faith to resolve any issues arising out of or in connection with the interpretation of this Agreement.

Licensor's Address:

1 Kotari-yakemachi, Nagaokakyo-City, Kyoto 617-8520, Japan

Semiconductor Business Division

Automotive & Industrial Systems Company

Panasonic Corporation

Important notice

Definitions

- The term "Guide" refers to all of the documents related to the LLC Reference Kit.
- The term "LLC Reference Kit" refers to all of the attached LLC Reference Board and other accessories.
- The term "LLC Reference Board" refers to all of the attached LLC Resonant Converter Board, MCU (Micro Control Unit) Control board, and their protective case.
- The term "LLC Resonant Converter Board" refers to the attached board (158 mm * 143 mm) on which GaN (Gallium Nitride)-based power transistor and other circuit components are implemented.
- The term "MCU Control Board" refers to the attached board (90.17 mm * 25.0 mm) on which Panasonic MCU is implemented.

Warnings

- Always turn off power first, and then disconnect all cables before carrying the LLC Reference Board. The failure of the above may cause damage, fire, or electric shock.
- Don't touch the LLC Reference Board directly with power applied. The part of board carries high voltage. The failure of the above may cause severe injury, disability, or death.
- Always turn off power before touching, servicing, or attaching cables or probes to the LLC Reference Board, except switching. The failure of the above may cause damage or fire.
- Be sure to comply with the "Startup Procedure" and "Shutdown Procedure" described in the Hardware Reference Guide to startup or shutdown the LLC Reference Board.
- Don't change the circuit component values of the LLC Reference Board. Changing values may cause malfunction, abnormal operation, or damage, smoke, or fire.
- Don't change settings for MCU with debugger. Changing the settings may cause malfunction, abnormal operation, damage, smoke, or fire.
- Don't leave the LLC Reference Board for more than 10 minutes while the power is ON. Otherwise, the heat generated by the circuit components may cause malfunction or burns.

Restrictions

- The LLC Reference Kit is intended for use as engineering development, verification, or evaluation purposes only. Don't use the kit except for checking the Basic Specifications and operation of the LLC circuit.
- The LLC Reference Kit must be used only by qualified engineers and technicians as below:

  - They are electronics-trained and experienced engineers, and familiar with risks associated with handling high-voltage electrical and mechanical components, electric circuits, and systems.

  - They observe good engineering practice standards.
- The LLC Reference Board is meant to be operated in the lab environment under the safe condition.
- Please use the LLC Reference Board in the state put in the protective case (accessory) when evaluating.

Cautions

- This Guide is the technical document for the LLC Reference Kit of Panasonic Corporation.
- The documents related to the LLC Reference Kit include the information for development purposes.
- All of the specifications and evaluation data in this Guide, except the Basic Specifications, are for reference only and not guaranteed.
- All information related to the LLC Reference Kit, including this Guide, are subject to change without notice. Please see the latest information for the Reference Kit.
- The LLC Reference Board is not intended for a finished end-product fit for general consumer use.

- Once a part on the board is removed, the LLC Reference Board is not included in the warranty.
- Carefully read the Guide with sufficient understanding prior to handling the LLC Reference Board.
- The LLC Reference Board must be used with necessary caution and appropriate safeguards employed to avoid personal injury or property damage.
- It is the user's responsibility to confirm that the voltages, isolation requirements, and rated value are identified and understood, prior to handling the board.
- When energized and evaluated, the LLC Reference Board, except switches for the protective case (attached), should not be touched.
- The LLC Reference Board should be handled by two or more engineers accompanied by an observer.
- To avoid heat burn and electrical shock, take enough time to confirm the heat dissipation and discharge after power off, and then handle the LLC Reference Board.
- Don't leave from the LLC Reference Board while power is applied.
- Don't do other operation near around the LLC Reference Board while power is applied.
- Please turn off power immediately on the occurrence of smoke generation, fire hazards, unusual odors or sounds by any chance while in use of the LLC Reference Board.
- It is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge when using the LLC Reference Board.
- The LLC Reference Board is not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards.
- Should the LLC Reference Board not meet the Basic Specifications indicated in the Guide, the board may be exchanged with the new one within 30 days from the date of delivery. When exchanging the LLC Reference Board, please return the board with all items included.
- For inquiries about the circuit components implemented on the LLC Reference Board or technical inquiries about the LLC Reference Board, please contact Panasonic staff or visit http://www.semicon.panasonic.co.jp/en
- The LLC Reference Kit does not include software and on-board debugger. For purchase, please contact Panasonic staff or visit http://www.semicon.panasonic.co.jp/en
- The LLC Reference Kit does not fall within the scope of the technical requirements of the following directives or other related directives.
  - Restriction of Hazardous Substances (RoHS)
  - Directive on Waste Electrical and Electronic Equipment (WEEE)
  - Mandatory conformity marking for products sold in the European Economic Area (CE)
  - Federal Communications Commission (FCC)
  - Underwriters Laboratories, Inc. (UL)
- The LLC Reference Board generates, uses, and can radiate radio frequency energy.
- The LLC Reference Board has not been tested for compliance with the limits of electronics devices pursuant to FCC rules, which are designed to provide reasonable protection against radio frequency interference.
- Operation of the LLC Reference Board in the environments other than laboratory may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

Chapter 1 Introduction

1

1.1 Overview and Features

Introduction

- This is a reference board for high resonant frequency LLC DC/DC converter that cannot be achieved by traditional semiconductor switching elements.
- This LLC Reference Board consists of a fast switching GaN power transistor and a MCU with high-resolution PWM for power control.
- With this LLC Reference Board, you can verify the following:
  1. Fast switching characteristic of our GaN power transistor
  2. Fast feedback loop control function of our 32-bit fast MCU for power control
  3. Feasibility of small and high-efficiency LLC DC/DC converter with high resonant frequency
     (To reduce the size of passive components, such as high-frequency transformer and capacitors)

Organization

- The guide is organized with the following two parts;
  1. Kit Reference Guide (this document), and
  2. Hardware Reference Guide

Features

- LLC Resonant Full-Bridge DC/DC Power Conversion
- Switching frequency: 1 MHz (typ.)
- Input voltage: 280 V to 400 V
- Output voltage: 260 V (typ.)
- Output current: 3.8 A (typ.)
- High Efficiency: more than 95% (Vin = 380 V, Vout = 260 V at 100% load)
- Functions:
  - Closed-loop control by feedback of output voltage
  - Soft start
  - Secondary side overload protection
  - Output overvoltage protection
  - Input voltage drop protection
  - Primary side overcurrent protection
  - Input overvoltage protection
- Target application: Various large-capacity DC-DC power systems for infrastructure, communication, industry, and automotive

1.2 Kit Contents

Before using the board, check that all of the following contents have been prepared.

1. LLC Reference Board 1
   LLC Resonant Converter Board
   MCU Control Board
   Protective case

2. AC adapter 1

3. Other
   Release note (Ver.1.0) 1
   LLC Reference Kit USER AGREEMENT & Important notice (Ver.1.0) 1
   CD-R (GaN LLC v1.0-001) 1
      - BOM ..... [BOM]
      - Schematics ..... [SCHEMATICS]
      - PCB Pattern ..... [PCB]
      - Evaluation data ..... [EVALUATION DATA]
      - Kit Reference Guide Ver.1.0 ..... <Kit_Reference_Guide_v1.0.pdf>
      - Hardware Reference Guide Ver.1.0 ..... <Hardware_Reference_Guide_v1.0.pdf>

1.3 Optional accessory products

The Reference LLC Kit does not include the following contents (optional accessory products).
For purchase, please contact Panasonic staff or visit http://www.semicon.panasonic.co.jp/en

Software Reference Kit
- Software Reference Guide..... 1
- Integrated Development Environment..... 1

Chapter 2 Specifications

2

Basic Specifications

Table 2-1. Basic Specifications

Parameter	Max	Typ	Min	Unit	Conditions
Rated input voltage	420	-	-	V	Input voltage Vin: 420 V or less
Guaranteed Operating Range					
Input voltage range	400	380	280	V	Transmitter (PQ50 Core), Vin = 380 V Output: 16 W to 500 W, Output voltage: 260 V ±5 V
Output voltage (260 V setting)	270	260	250	V	Transmitter (PQ50 Core), MCU output setting: 260 V, Vin = 380 V, Output: 16 W to 1 kW
Protect Function					
Input voltage drop protection (brown in)	265	-	-	V	When the input voltage is 265 V or less, sets the FU_G, FL_G, RU_G, and RL_G outputs to low so as to make the inverter outputs Fo and Ro low.
Input overvoltage protection	-	-	415	V	When the input voltage is 415 V or more, sets the FU_G, FL_G, RU_G, and RL_G to low so as to make the inverter outputs Fo and Ro low.
Output overvoltage protection	-	-	340	V	When the output voltage is 340 V or more, sets the FU_G, FL_G, RU_G, and RL_G outputs to low so as to make the inverter outputs Fo and Ro low.

Reference data for design

The data in the table below are for reference only, including the target values in our product development. Therefore, their value is not guaranteed by the test.

Table 2-2. Reference data for design

Parameter	Max	Typ	Min	Unit	Conditions
Switching frequency range	1500	1000	700	kHz	Transmitter (PQ50 CORE), no rectifier circuit, no FB control , and Vin = 380 V
Output voltage (300 V setting)	310	300	290	V	Transmitter (PQ50 CORE), MCU output setting = 300 V, Vin = 380 V, and output = 1 kW
Output voltage ripple	-	0.8	-	%	Transmitter (PQ50 CORE), Vin = 380 V, and output = 260 V/1 kW
Efficiency at 100% load (1 kW)	-	96	-	%	Transmitter (PQ50 CORE), Vin = 380 V, and output = 260 V
Soft-start frequency	-	1000	-	kHz	Shift the phase of the RO half-bridge output from 0° to 180° in 3° increments at Fsw = 1 MHz
Setting time for output voltage	-	64	-	ms	Time to reach the output level of 260 V/1 kW after 380 V is applied to Vin
Primary overcurrent protection	-	-	15	A(p-p)	When the primary current of transformer T1 is 15 A or more, sets the FU_G, FL_G, RU_G, and RL_G outputs to low so as to make the inverter outputs Fo and Ro low.
Secondary overload protection	-	-	5	A	When the secondary current of transformer T1 is more than 5A, sets the FU_G, FL_G, RU_G, and RL_G outputs to low so as to make the inverter outputs Fo and Ro low.

Other Functions

- Closed-loop control by feedback of output voltage
- Switching on/off
- Output protection for the non maskable interrupt of a MCU

Chapter 3 Other information

3

3.1 Visual Appearance of Each Board

LLC Resonant Converter Board

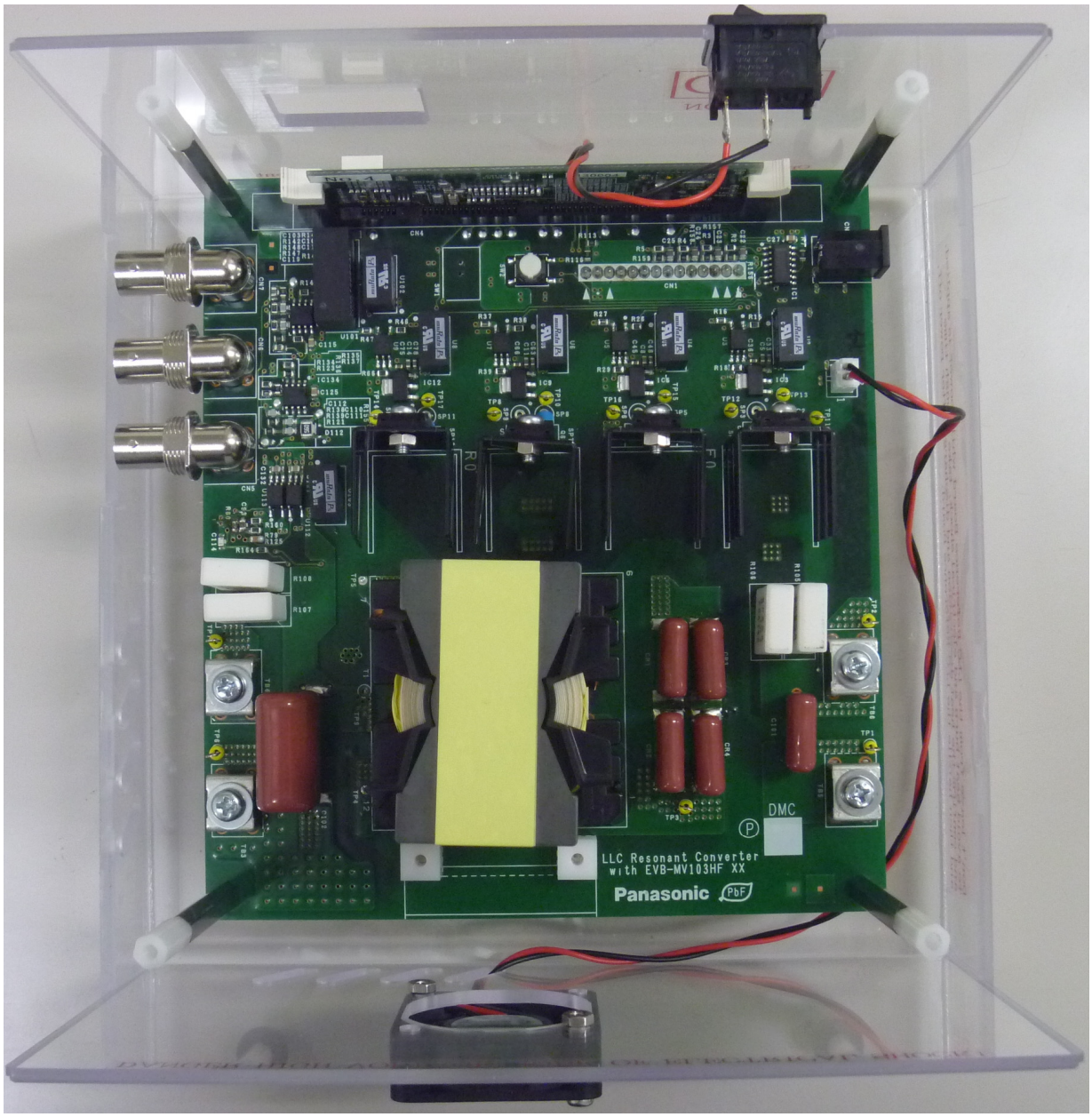

Fig3-1. Visual Appearance of LLC Resonant Converter Board (Component side)

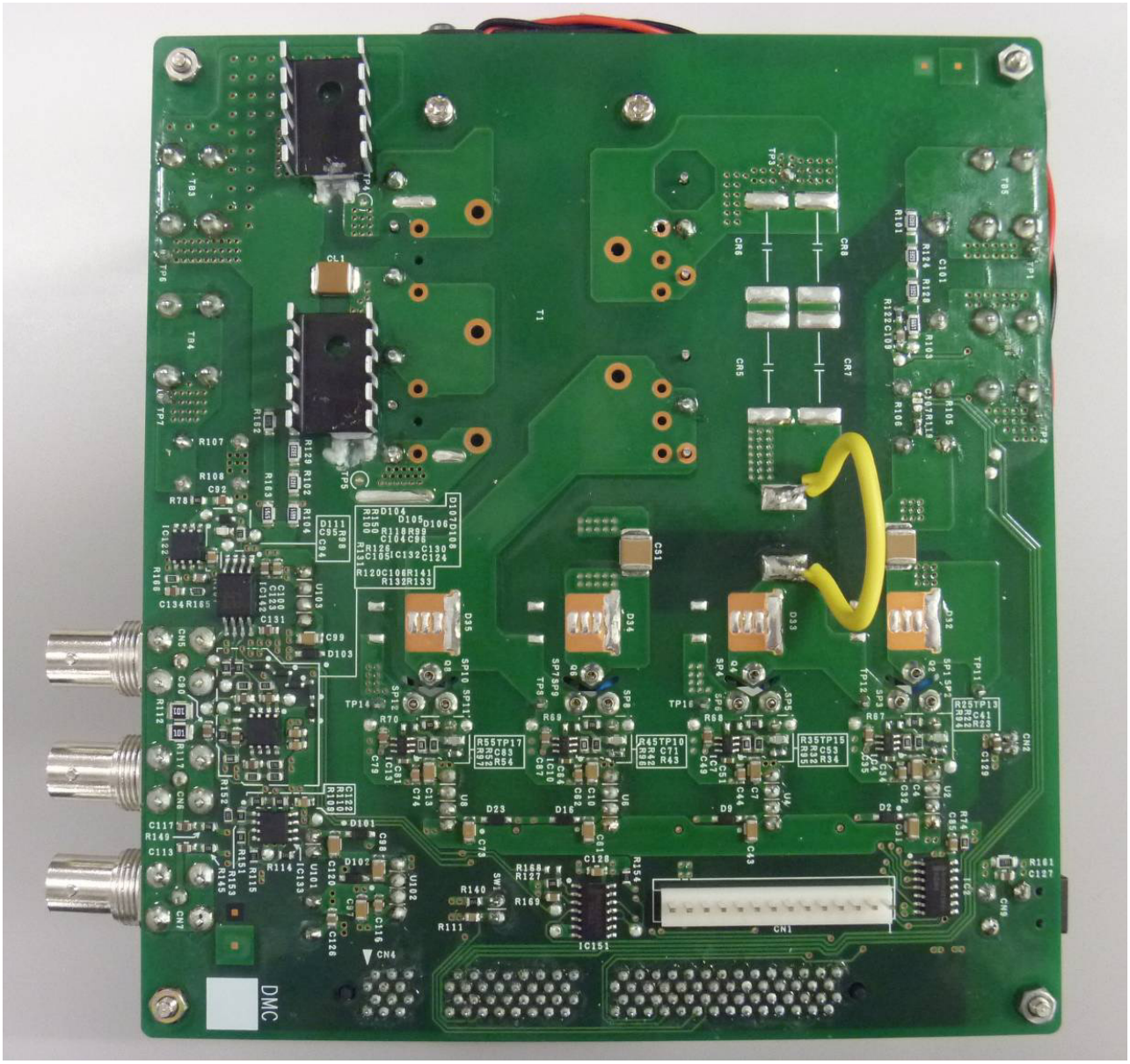

Fig3-2. Visual Appearance of LLC Resonant Converter Board (Solder side)

MCU Control Board

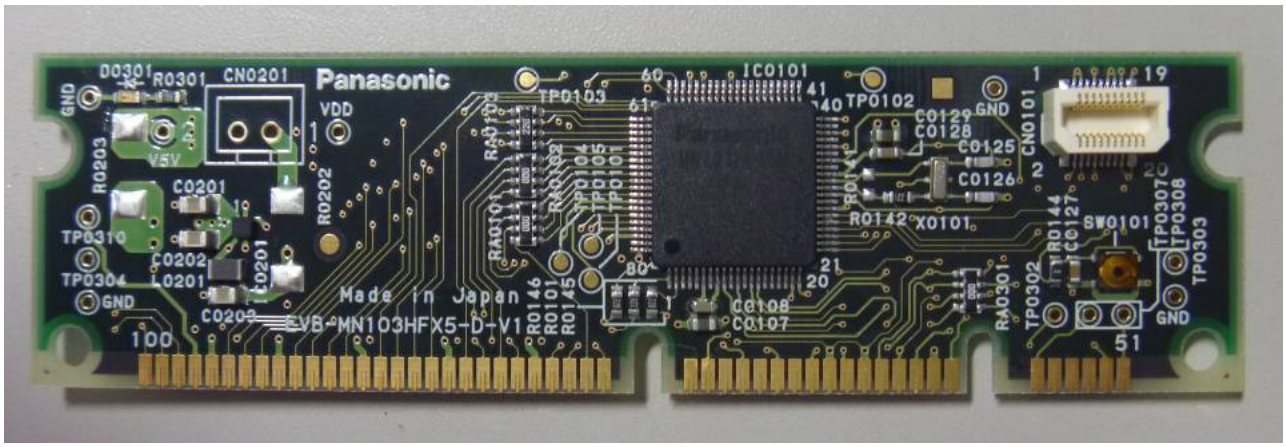

Fig3-3. Visual Appearance of MCU Control Board (Component side)

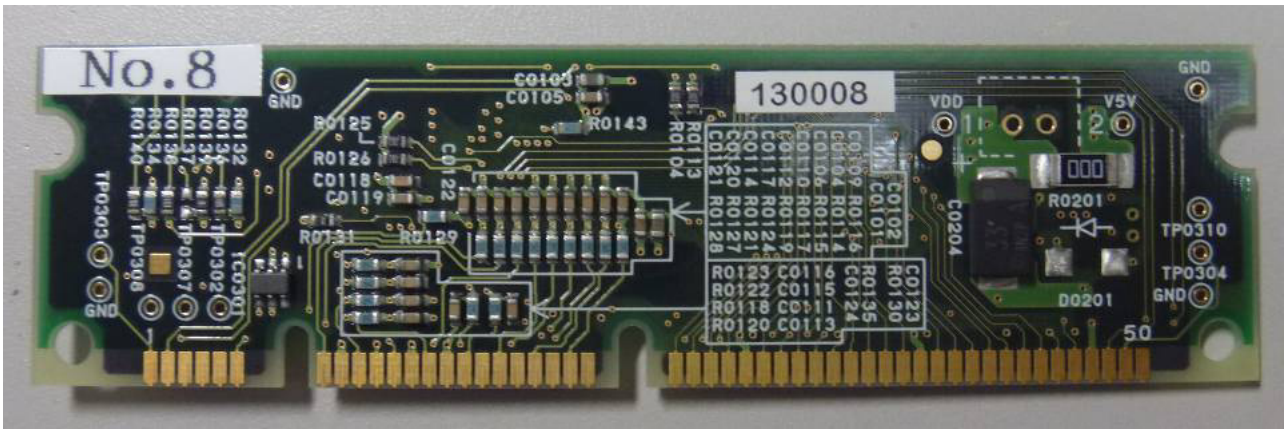

Fig3-4. Visual Appearance of MCU Control Board (Solder side)

3.2 Pins and Connectors

3.2.1 Pin Information

Table 3-1. Test Pins for LLC Resonant Converter Board

Reference Numbers	Description
TP1	Input voltage (+) monitor
TP2	Input voltage (-) monitor
TP3	Transformer primary voltage monitor
TP4	Transformer secondary voltage monitor
TP5	Transformer secondary voltage monitor
TP6	Output voltage (+) monitor
TP7	Output voltage (-) monitor
TP8	Inverter output voltage (RO) monitor
TP9	Transformer secondary voltage (center tap) monitor
TP10	Gate voltage (Q6) monitor
TP11	Drain voltage (Q2) monitor
TP12	Inverter output voltage (FO) monitor
TP13	Gate voltage (Q2) monitor
TP14	Source voltage (Q4) monitor
TP15	Gate voltage (Q4) monitor
TP16	Source voltage (Q8) monitor
TP17	Gate voltage (Q8) monitor

3.2.2 Connector information

Table 3-2. Connectors for LLC Resonant Converter Board

Reference Numbers	Description
CN1	PWM drive signal input
CN2	Power-supply voltage applied for fan
CN4	Connected to the control board
CN5	Open loop gain measurement signal input
CN6	Open loop gain measurement signal (input) monitor
CN7	Open loop gain measurement signal (output) monitor
CN9	Connected to AC adapter
TB3	Load (+) applied
TB4	Load (-) applied
TB5	Input voltage (+) applied
TB6	Input voltage (-) applied

3.3 Reference

Contents of CD-R

The attached CD-R has other reference information about LLC Resonant Converter Board and MCU Control Board, as follows:

TOP Directory

Contents (Reference Guides)	Version
Kit_Reference_Guide_v1.0.pdf	Ver.1.0
Hardware_Reference_Guide_v1.0.pdf	Ver.1.0

BOM

Contents (BOM Lists)	Version
BOM_LLC_Resonant_Converter_Board_v1.0.pdf	Ver.1.0
BOM_MCU_Control_Board_v1.0.pdf	Ver.1.0

SCHEMATICS

Contents (Schematics)	Version
SCH_LLC_Resonant_Converter_Board_v1.0.pdf	Ver.1.0
SCH_MCU_Control_Board_v1.0.pdf	Ver.1.0

PCB

PCB_LLC_Resonant_Converter_Board_v1.0

Contents (PCB Patterns)	Version
TOP_PAT_v1.0.pdf	Ver.1.0
BOT_PAT_v1.0.pdf	Ver.1.0
IN1_PAT_v1.0.pdf	Ver.1.0
IN2_PAT_v1.0.pdf	Ver.1.0
TOP_SILK_v1.0.pdf	Ver.1.0
BOT_SILK_v1.0.pdf	Ver.1.0
OUTLINE_v1.0.pdf	Ver.1.0

PCB_MCU_Control_Board_v1.0

Contents (PCB Patterns)	Version
LAYOUT_v1.0.pdf	Ver.1.0

EVALUATION DATA

Contents (Evaluation data)	Version
Evaluation_Data_v1.0.pdf	Ver.1.0

Fig 3-5. Reference Information

Support information

- Panasonic Microcomputer Technical Support Page
  http://www.semicon.panasonic.co.jp/e-micom

- MCU MN103HF33/34/35/36/37/38 Series LSI User's Manual Vol.1 (*1)
  http://www.semicon.panasonic.co.jp/en/support/manuals/manual_micom_mn103s_detail_13625.html

- MCU MN103HF33/34/35/36/37/38 Series LSI User's Manual Vol.2 (*2)
  http://www.semicon.panasonic.co.jp/en/support/manuals/manual_micom_mn103s_detail_13628.html

  *1,2 User registration for **Semiconductor Support System** is required for download.

Inquiries

If you have questions regarding technical information on this manual, please visit the following URL.

Panasonic Corporation

URL: http://www.semicon.panasonic.co.jp/en

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